# Quantitative Precipitation Estimation Using X and S-band Dual Polarization Radar: Implications for HMT
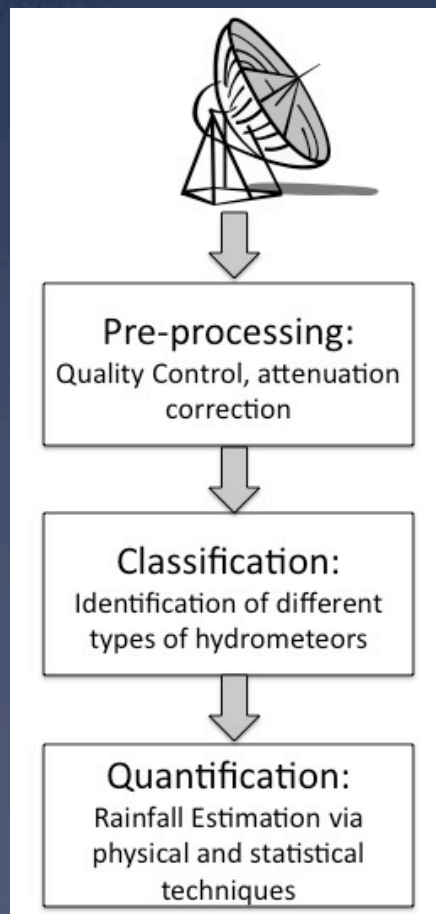
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# Advantages of dual polarization radar systems

- ## Basic science issues
  *More accurate models to represent the DSD and their relationship to radar variables*

- ## Applied science issues
  *Measurements that are immune to absolute radar calibration, partial beam blocking, and can aid in data quality enhancement (QC)*

# Dual polarization observations can be integrated into all 3 steps of the QPE process to improve rainfall estimation



Pre-processing:
Quality Control, attenuation correction

Classification:
Identification of different types of hydrometeors

Quantification:
Rainfall Estimation via physical and statistical techniques

- Pre processing (data enhancement)

- Classification (identification of different hydrometeor types)

- Quantification (rainfall estimation)

# Dual polarization achieves robust QPE by combining different radar measurements

Take advantage of strength of rainfall estimators in different precipitation environments

- *Radar reflectivity ($Z_h$)*
- *Differential reflectivity ($Z_{dr}$)*
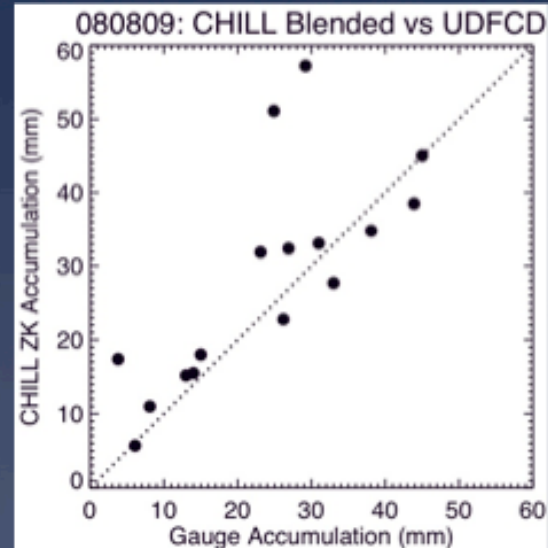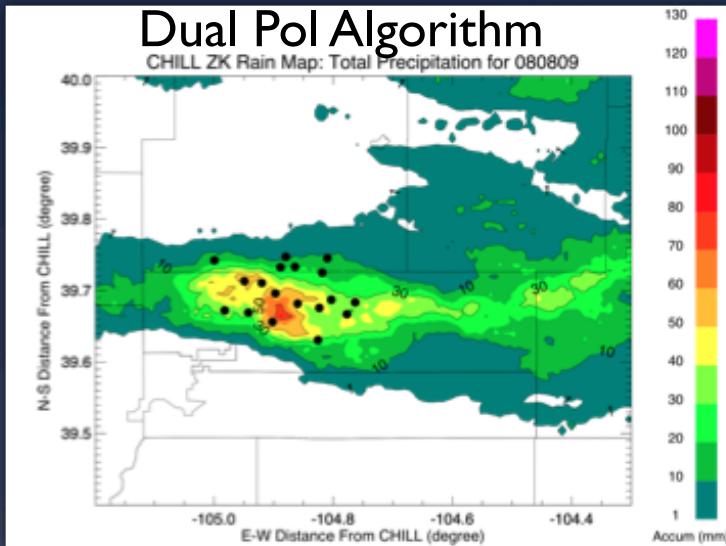- *Specific differential phase ($K_{dp}$)*

# Dual polarization QPE algorithms at S-band have been developed over several decades

- Advantages of S-band systems
  *minimal attenuation*

- Disadvantages of S-band systems
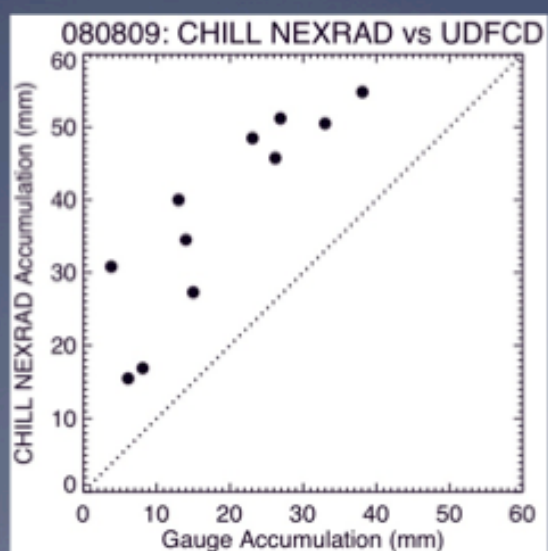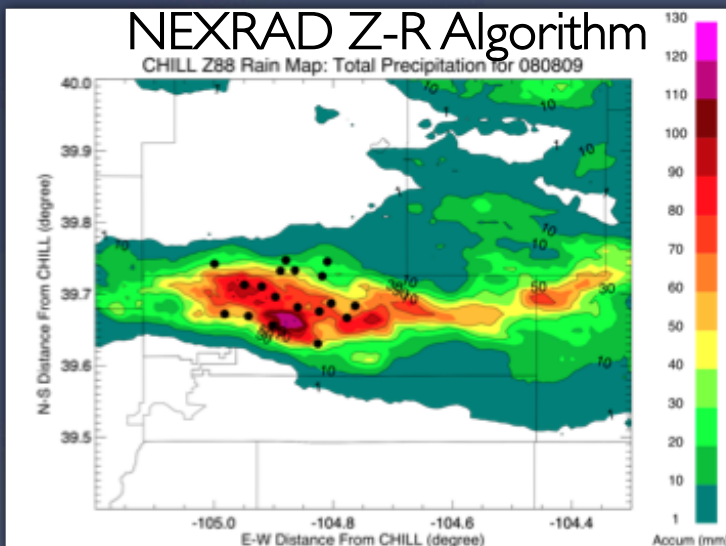  $K_{dp}$ *sensitivity limit*
  *big footprint*

# Example of S-band QPE performance:
## Rainfall accumulation
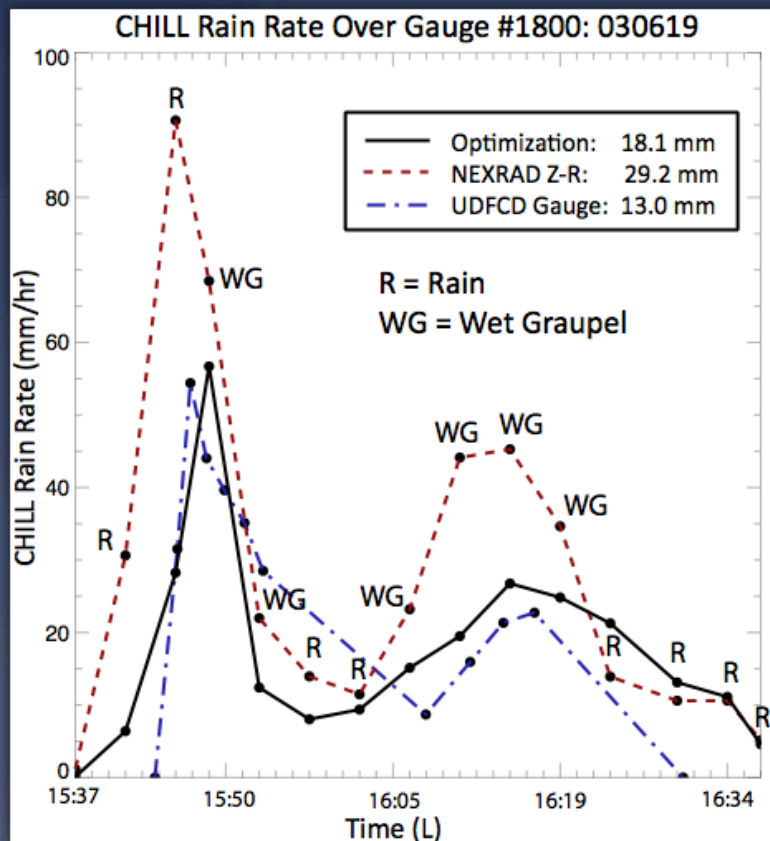


**Dual Pol Algorithm**



- Dual pol QPE in good agreement with gauges

**NEXRAD Z-R Algorithm**



- Z-R overestimates QPE due to ice contamination

# Example of S-band QPE performance: Rain rate



CHILL Rain Rate Over Gauge #1800: 030619

- Optimization: 18.1 mm
- NEXRAD Z-R: 29.2 mm
- UDFCD Gauge: 13.0 mm

R = Rain
WG = Wet Graupel

- Z-R overestimates when precipitation ice is present

- Dual-polarization adjusts rainfall estimator based on HID

# X-band radar has emerged as important tool for QPE

- Advantages of X-band systems
  *portability*
  *increased sensitivity to phase estimator of rainfall ($K_{dp}$)*

- Disadvantages of X-band systems
  *attenuation in heavy rain*
  *typically cover a smaller area than S-band*

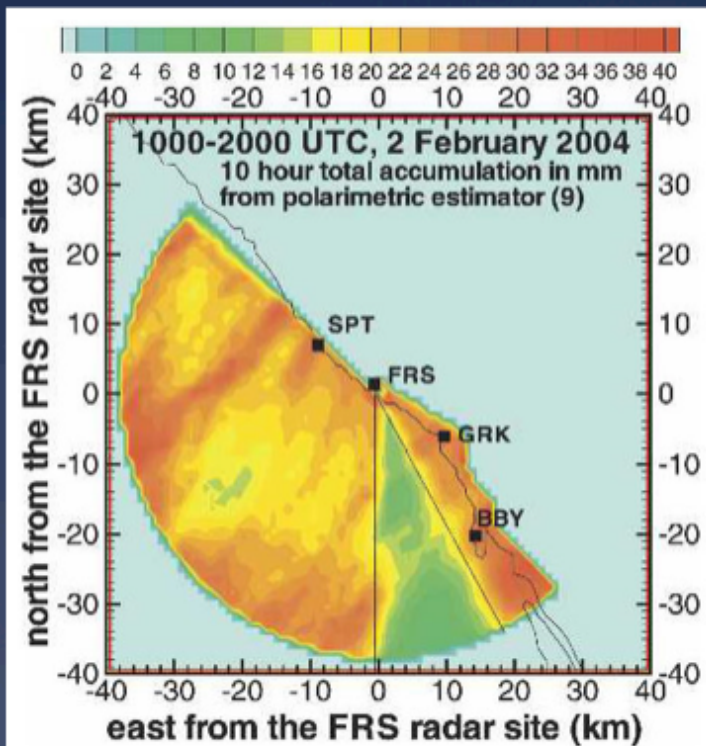# NOAA X-band QPE example: HMT-2004



FIG. 12. A map of the total rainfall accumulation for the 2 Feb 2004 event obtained from X-band radar data. The sector between the straight black lines at 150° and 180° was partially blocked by the radar trailer.
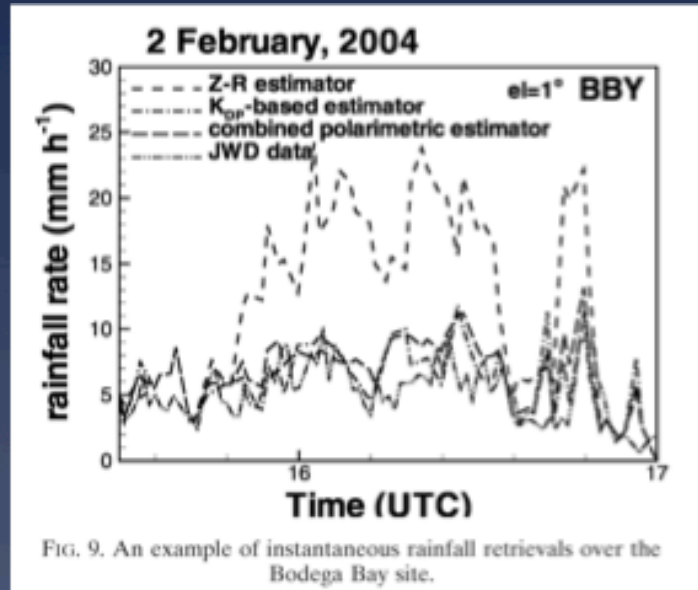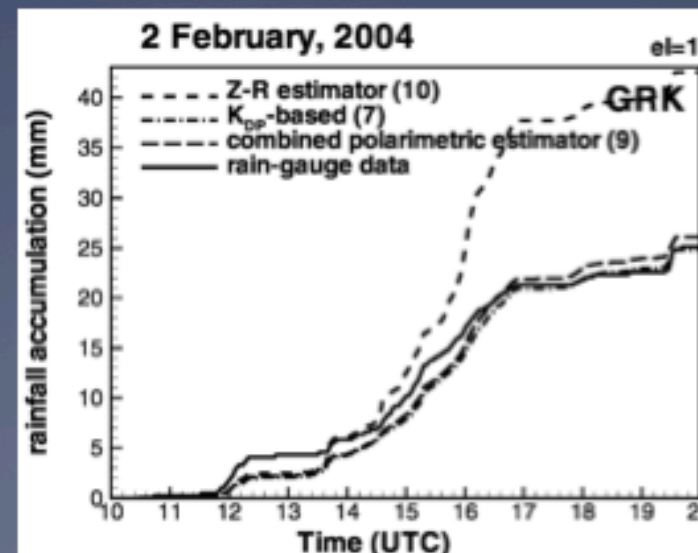


FIG. 9. An example of instantaneous rainfall retrievals over the Bodega Bay site.



- Z-R overestimates compared to disdrometer

- Dual-pol in much better agreement with disdrometer

From Matrosov et al. 2005

# X-band network QPE: CASA

- Integrated Project 1 (IP1) network in central OK with 4 X-band radars under the umbrella of KOUN S-band

- multiple radars operating at short range (40 km)
  *multiple "looks" (optimal attenuation correction)*
  *beam height remains low (<1 km AGL)*

- update time 60s

- range resolution <100m

- QPE using $K_{dp}$ (relative insensitivity to attenuation)

# CASA Network Design
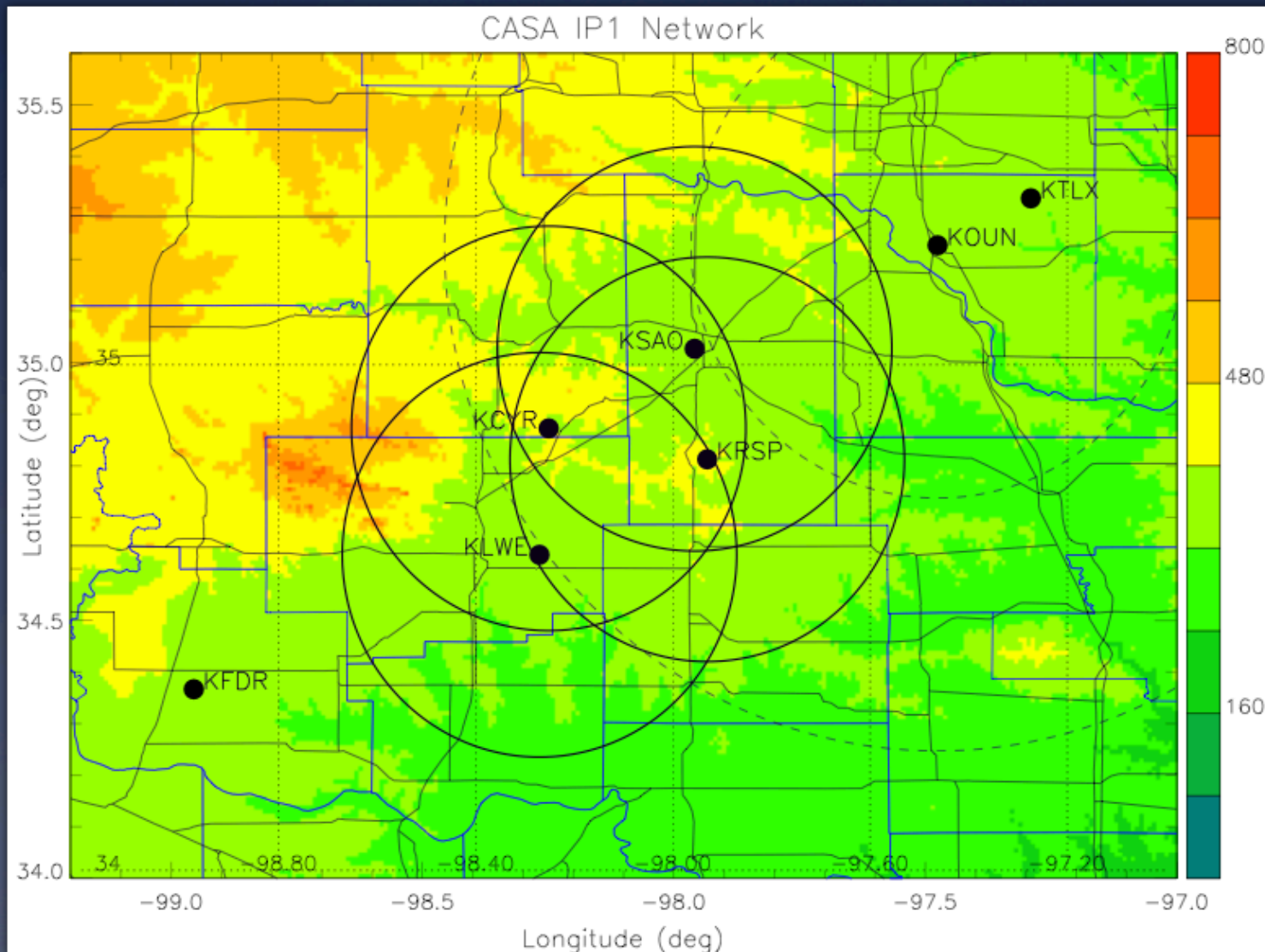


CASA IP1 Network

# CASA network QPE performance

## Hourly rainfall accumulation using $R(K_{dp})$

| Radar Network | Total Events Analyzed | Normalized Bias (%) | Normalized Standard Error (%) | |
|---|---|---|---|---|
| KOUN (JPOLE) | 24 | -10.3 | 58.9 | Ryzhkov et al. (2005) |
| CASA IP1 | 29 | 4.3 | 22.8 | Wang and Chandrasekar (2010) |

- NSE ~3X improvement compared to similar estimates from S-band dual polarization radar (KOUN)

# X-band radar has great potential for QPE

- Networks of X-band systems will play increasing role in operational QPE

    *CASA - NIED partnership for flood monitoring (X-NET in Tokyo Japan)*

- Serve as "gap filling" radars in operational networks

    *Produce high resolution QPE for hydrological applications in both urban and rural (watershed-scale) regions*